

# 2018 U.S. DEPARTMENT OF ENERGY SOLID-STATE LIGHTING R&D WORKSHOP AGENDA

January 29–31, 2018 • Nashville, TN

## MONDAY, JANUARY 29

7:00 a.m. *Registration Opens and Continental Breakfast*

### PLENARY SESSIONS

8:00 a.m. **WELCOME AND INTRODUCTION**

While reduced energy consumption is now expected from solid-state lighting sources, the possibilities and impact of SSL go well beyond simple energy savings at the source level. SSL technology has the potential to deliver light much more effectively, saving further energy and improving human well-being. These additional benefits can be achieved while source efficiency continues to improve, offering even more savings at the light source level.

JAMES BRODRICK, U.S. DEPARTMENT OF ENERGY

8:30 a.m. **INNOVATIONS IN LED LIGHTING**

As LED lighting technology continues to make strides in terms of price and performance, innovative new features continue to broaden the impact of SSL beyond just energy savings into arenas such as connectivity, data analytics, horticulture, and human health and well-being. This talk will share insights in R&D advances at the LED, luminaire, and application levels, and explore the challenges that remain in the path of continued growth, connectivity, and the road to 250 lm/W.

MATTHIAS SABATHIL, OSRAM

9:15 a.m. **LED SCIENCE AND TECHNOLOGY ADVANCEMENTS**

LED package technology and underlying scientific understanding continue to advance. Our understanding of the underlying materials science and physics of droop, green gap, red LED, amber LED, and quantum dots is clarifying, enabling significant technology advancements. This talk will cover some recent R&D in these areas and explore how these advancements will improve the application of LED lighting.

WERNER GOETZ, LUMILEDS

10:00 a.m. *Refreshment Break*

10:30 a.m. **PANEL | THE FUTURE OF LIGHTING EFFICACY**

Lighting efficacy has been traditionally associated with how efficiently light is created, regardless of how it is distributed and used for human vision. As solid-state lighting continues to advance, it will give us new abilities to control the space/time/spectral distribution of light and how it interacts with human vision. What will “lighting efficacy” mean in this new world? Can we determine (and measure and implement) space/time/spectral distributions of light that optimize user visual satisfaction and/or productivity for various activities, while at the same time minimizing energy

consumption? This panel discusses these questions from the perspectives of lighting design, computational light modeling, and the human physiology of vision.

MODERATOR: JEFF TSAO, SANDIA NATIONAL LABORATORIES  
DARCIE CHINNIS, HLB LIGHTING DESIGN  
KEVIN HOUSER, PENNSYLVANIA STATE UNIVERSITY  
PRADEEP SEN, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

*Noon*

*Lunch*

1:00 p.m.

**PANEL | UNDERSTANDING THE EFFECTS OF LIGHT ON HUMAN PHYSIOLOGY IN REALISTIC SETTINGS**

The understanding of how light can affect physiological responses has expanded dramatically in the last 15 years, and much of that understanding derives from controlled laboratory studies. While some lighting practitioners are attempting to apply the laboratory findings to field applications, the evidence base documenting physiological responses in realistic settings has been very limited. In this panel discussion we'll hear from leading researchers who will explain recent findings that build on what is "known" about the physiological effects of light and will identify what research is necessary to fill gaps in understanding.

MODERATOR: BOB DAVIS, PACIFIC NORTHWEST NATIONAL LABORATORY  
SHADAB RAHMAN, HARVARD MEDICAL SCHOOL  
JENNIFER VEITCH, NATIONAL RESEARCH COUNCIL CANADA  
RON GIBBONS, VIRGINIA TECH TRANSPORTATION INSTITUTE  
GENA GLICKMAN, UNIVERSITY OF CALIFORNIA, SAN DIEGO

2:30 p.m.

**BALANCING PERFORMANCE, SAFETY, ENERGY SAVINGS, HEALTH, AND ECOLOGICAL IMPACTS FOR ROADWAY LIGHTING**

With the introduction of LED technology, roadway lighting products and design are now expected to consider roadway safety, connectivity and control, human physiological impacts of light, sky glow, ecological impacts, light trespass, and, of course, efficiency, cost, and maintenance. This talk will cover the latest guidance for all these considerations, conflicts between new considerations and recommended practices, and suggested R&D and paths forward to get the best of all worlds with roadway lighting.

PAUL LUTKEVICH, WSP

3:15 p.m.

*Refreshment Break*

## RUMP SESSIONS — Open discussion and Q&A

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| 3:45 p.m. | <b>WORKING WITH THE DOE SSL PROGRAM</b><br>Open discussion and Q&A regarding the DOE SSL FOA process, the SBIR grant process, and the collaborative OLED testing opportunity.<br>JOEL CHADDOCK, NATIONAL ENERGY TECHNOLOGY LABORATORY | <b>BRIDGING R&amp;D EFFORTS RELATED TO LIGHT AT NIGHT, SKY GLOW, AND ANIMAL RESPONSES TO LIGHT</b><br>Open discussion and Q&A on current research efforts to understand and mitigate sky glow and ecological impacts on nocturnal wildlife, and what is needed moving forward.<br>JEFF TSAO, SANDIA NATIONAL LABORATORIES<br>BOB DAVIS, PACIFIC NORTHWEST NATIONAL LABORATORY<br>DIANNE INGRAM, U.S. FISH & WILDLIFE SERVICE | <b>RESEARCH FOR CONNECTED LIGHTING</b><br>Open discussion and Q&A on opportunities to speed the development of connected lighting systems.<br>MONICA HANSEN, LED LIGHTING ADVISORS<br>MARK HAND, ACUITY BRANDS<br>DORENE MANICCIA, PHILIPS<br>MICHAEL POPLAWSKI, PACIFIC NORTHWEST NATIONAL LABORATORY |
|-----------|---|--|--|

5:30 p.m. *Adjourn*

## TUESDAY, JANUARY 30

7:00 a.m. *Continental Breakfast*

## PLENARY SESSIONS

|           |   |
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| 8:00 a.m. | <b>USING MORE DATA FOR LIGHTING SCIENCE</b><br>This talk will review some recent large scale epidemiological work, discuss the potential benefits of gathering larger sets of evidence, review other large-scale data approaches, and suggest new technological approaches that can enable low-cost collection of larger sets of lighting data.<br>SHADAB RAHMAN, HARVARD MEDICAL SCHOOL  |
| 8:30 a.m. | <b>PANEL   R&amp;D DIRECTIONS OF COLOR-TUNABLE LIGHTING</b><br>Solid-state lighting offers new levels of engineering control over light spectra that may offer non-energy benefits to support human health and well-being, increased productivity, and enhanced mood or alertness, and that can provide a visually dynamic lighting environment. This panel will explore the technology challenges associated with tunable lighting, including methods of color mixing, multi-channel driver development, novel color sensors, and the testing required to characterize a color-tunable product.<br>MODERATOR: MONICA HANSEN, LED LIGHTING ADVISORS<br>STEVE PAOLINI, TEDELUMEN<br>MATT WEAVER, LUMENETIX<br>PAYMAN ZARKESH-HA, UNIVERSITY OF NEW MEXICO<br>CHAD STALKER, ACUITY BRANDS |

10:00 a.m. Refreshment Break

## TRACK SESSIONS

### 10:30 a.m. LED TRACK I: LED AND DOWNCONVERSION MATERIALS

Materials are at the heart of solid-state lighting—both the InGaN materials from which blue light direct emitters are currently fabricated, and the wavelength-downconversion materials from which green-yellow-red light indirect emitters are currently fabricated. In this session, we review the states of the art and challenges associated with these materials. Potential research opportunities—including novel approaches to mitigating efficiency droop, to efficient direct emission in the green-yellow-red, to narrow-linewidth downconversion in the red, and to downconversion at high light fluxes—will then be discussed, with plenty of room for audience engagement and input.

MODERATOR: JEFF TSAO, SANDIA NATIONAL LABORATORIES

JAMES MURPHY, GE GLOBAL RESEARCH  
PETER PALOMAKI, PALOMAKI CONSULTING  
ISAAC WILDESON, LUMILEDS  
MANOS KIOUPAKIS, UNIVERSITY OF MICHIGAN

### OLED TRACK I: ORGANIC STACK

The goal of the stack is to convert electric current into light and create a large area surface source. This session will examine options for advances including improvements in the traditional vapor deposited emitters and transport materials and solution-processed materials. Metrics and status for efficacy, color gamut, and reliability will also be discussed.

MODERATOR: LISA PATTISON, SSLS, INC.  
STEVE FORREST, UNIVERSITY OF MICHIGAN  
LARISSA BERGMANN, CYNORA  
MICHELE RICKS, EMD PERFORMANCE MATERIALS  
CHRIS GIEBINK, PENNSYLVANIA STATE UNIVERSITY

12:30 p.m. Lunch

### 1:30 p.m. LED TRACK II: ADVANCED LED PRODUCT CONCEPTS

Research and development of new technology has resulted in the development of new advanced LED lighting products. This panel will discuss the impact of new LED source and optical control methods to enable new products or more efficient design in areas from headlights to white tunable luminaires.

MODERATOR: MONICA HANSEN, LED LIGHTING ADVISORS  
BRIAN CUMPSTON, BRIDGELUX  
PAUL FINI, CREE  
BENNO SPINGER, LUMILEDS  
OMAR RIVERA, MVP CONSULTING GROUP

### OLED TRACK II: CONCEPTS FOR OLED MANUFACTURING

Traditional OLED manufacturing methods are too expensive and restrictive in terms of OLED form factor. This panel will discuss new approaches needed to facilitate the production of flexible panels of arbitrary shape, decrease processing times, increase yields, and reduce waste.

MODERATOR: NORMAN BARDSLEY, BARDSLEY CONSULTING  
JOHN HAMER, OLEDWORKS  
NEETU CHOPRA, KATEEVA

3:30 p.m. Refreshment Break

4:00 –  
6:30 p.m.

## **POSTER SESSION**

Project posters will be presented by research team representatives, providing an opportunity for one-on-one discussions with SSL's leading scientists.

### **PRESENTERS AND EXHIBITORS**

|                                       |  |
|---------------------------------------|--|
| Arizona State University              | Pennsylvania State University                                    |
| Columbia University                   | Philips Lighting North America                                   |
| Cree                                  | PhosphorTech   |
| GE Global Research                    | Pixelligent  |
| Georgia Institute of Technology       | RPI Center for Lighting Enabled Systems<br>& Applications (LESA) |
| Iowa State University                 | RTI International  |
| Lucent Optics                         | SC Solutions   |
| Lumenari                              | Telelumen  |
| Lumileds                              | University of California, Los Angeles                            |
| Luminit                               | University of California, San Diego                              |
| Lumisyn                               | University of California, Santa Barbara                          |
| MicroLink Devices                     | University of Michigan   |
| Mojo Labs                             | University of New Mexico   |
| National Energy Technology Laboratory | University of Southern California                                |
| Navigant Consulting                   | Virginia Polytechnic Institute and State<br>University           |
| North Carolina State University       | Voltserver   |
| OLEDWorks                             |  |
| Pacific Northwest National Laboratory |  |

### **STUDENT POSTER COMPETITION WINNERS**

Juan (Rachel) He, University of Central Florida  
Taehwan Kim, Pennsylvania State University  
Shima Nezhadbadeh, University of New Mexico  
Kwing Tong, University of California, Los Angeles

## WEDNESDAY, JANUARY 31

7:00 a.m. Continental Breakfast

### TRACK SESSIONS

8:00 a.m.

#### **LED TRACK III: ADVANCED LED MANUFACTURING**

This session will hear about advancements in MOCVD technology, phosphor synthesis, and flexible luminaire manufacturing, followed by a discussion of critical manufacturing R&D that can reduce cost-consistency-performance trade-offs and have the added benefit of promoting domestic manufacturing.

MODERATOR: MORGAN PATTISON, SSLS, INC.  
CHRIS MORATH, VEECO  
KAMAL HADIDI, AMASTAN  
STAN WEAVER, GE

#### **OLED TRACK III: INTEGRATION**

This session will explore the addition of connectors, drivers, and mechanical supports to create luminaires or to integrate panels into other structures, such as furniture or vehicles. The value of modules or light engines will be explored and the demands of various applications will be examined.

MODERATOR: NORMAN BARDSLEY,  
BARDSLEY CONSULTING  
JAY EISSNER, VISA LIGHTING  
MELANIE KIMSEY-LIN, BOEING  
MIKE FUSCO, LED SPECIALISTS

10:00 a.m. Refreshment Break

10:30 a.m.

#### **LED TRACK IV: LIGHTING SCIENCE**

In 2017, physiological impacts of light and lighting application efficiency were suggested as two priority R&D topics. The SSL revolution has challenged our fundamental understanding of these and other areas of lighting science. It is critical to understand the lighting science for all lighting applications to know how best and most efficiently to provide light. In this session, we'll hear some of the latest research and industry committee activities related to color science, temporal light artifacts (e.g., flicker), and glare. And, we'll have an open discussion about priorities for future research in these and other lighting science topic areas.

MODERATOR: BOB DAVIS, PACIFIC  
NORTHWEST NATIONAL LABORATORY  
GILLES ABRAHAMSE, ELDOLED  
YOSHI OHNO, NATIONAL INSTITUTE OF  
STANDARDS AND TECHNOLOGY  
BRAD SCHLESSELMAN, MUSCO LIGHTING

#### **OLED TRACK IV: SUPPORTING MATERIALS**

The foundation for the organic stack is a substrate with a light extraction enhancement structure and transparent anode. Plastic substrates also require a barrier to prevent ingress of oxygen and water. Research is needed to improve the performance of each component and to ensure that reliable OLEDs can be deposited on this foundation and adequately sealed. This session will explore these supporting components and identify metrics to compare various approaches.

MODERATOR: LISA PATTISON, SSLS, INC.  
GREG COOPER, PIXELLIGENT  
RUTH SHINAR, IOWA STATE UNIVERSITY  
JUAN RUSSO, LUMINIT  
YUE QU, UNIVERSITY OF MICHIGAN

12:30 p.m. Lunch

## PLENARY SESSION

1:30 p.m.

### **PANEL | ENHANCED FUNCTIONALITY AND BUILDING INTEGRATION**

The convergence of SSL and the IoT provides a connected lighting platform that can change the way we light and use buildings. Connectivity harnesses technologies such as lighting controls, sensors, and data analytics that not only create enhanced functionality and energy savings but offer non-energy benefits as well. This panel will explore the technology challenges associated with building integration of new SSL form factors, a connected lighting building platform, and the use of these technologies for enhancing user preference.

MODERATOR: MONICA HANSEN, LED LIGHTING ADVISORS  
DORENE MANICCIA, PHILIPS LIGHTING  
KELLY GORDON, PACIFIC NORTHWEST NATIONAL LABORATORY  
RICHARD RADKE, RENSSELAER POLYTECHNIC INSTITUTE

3:00 p.m.

*Adjourn*